Purpose: To assess the feasibility of an online adaptive proton therapy technique for discrete spot scanning proton therapy (SSPT) to correct for interfractional anatomic changes.

Methods: An adaptive algorithm was developed to compensate for range changes without full reoptimization. The individual spot energies from the original treatment plan were adjusted to match the new anatomy based on the water equivalent pathlength to the distal edge of the target on a ray-by-ray basis. Remaining spots outside of (proximal- and lateral-to) the target were then removed or spots were added if necessary. The newly adapted plan was imported back to the treatment planning system for dose computation using the new spot arrangement. Three lung patients were selected with targets of variable sizes in the right upper lobe and a single beam (Right Lateral) SSPT plan was tested using this approach. These patients were selected based on large anatomical changes over the course of treatment, with an average GTV and CTV shrinkage of 38% and 19%, respectively, by the end of treatment. A total of 19 weekly CT images were analyzed.

Results: The dose to normal tissue, especially distal to the target, was reduced after applying the proposed adaptive technique. The maximum improvement in mean and V20Gy contralateral lung dose between the adapted and non-adapted plans were 13.4Gy and 18.6Gy, respectively. The maximum improvement in spinal cord Dmax and D1cc were 31.2Gy and 38.9Gy, respectively. Target coverage decreased for both the adapted and non-adapted plans, but the D95% target dose for the adapted plan remained ≥80% while the D95% target dose for the non-adapted plans dropped to as low as 43.1%.

Conclusions: The adaptive procedure shows promise to reduce normal tissue doses and improve target coverage without a full reoptimization. Improvement in spot adjustment strategy may be needed to further improve target coverage.
Funding support provided by: The University of Texas Graduate School of Biomedical Sciences at Houston and the University of Texas MD Anderson Cancer Center, Houston, TX. Supported in part by NCI P01CA021239-29A1.